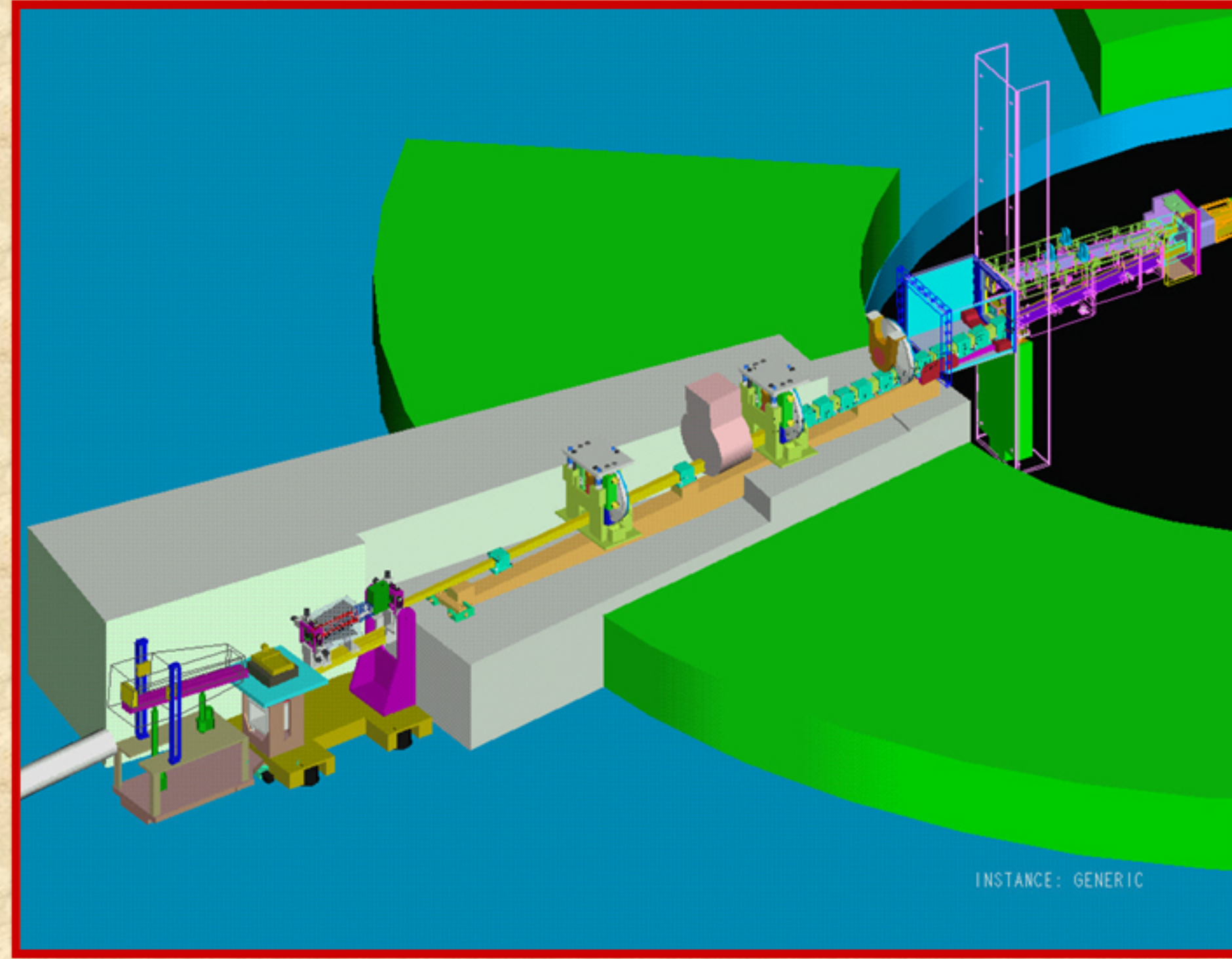


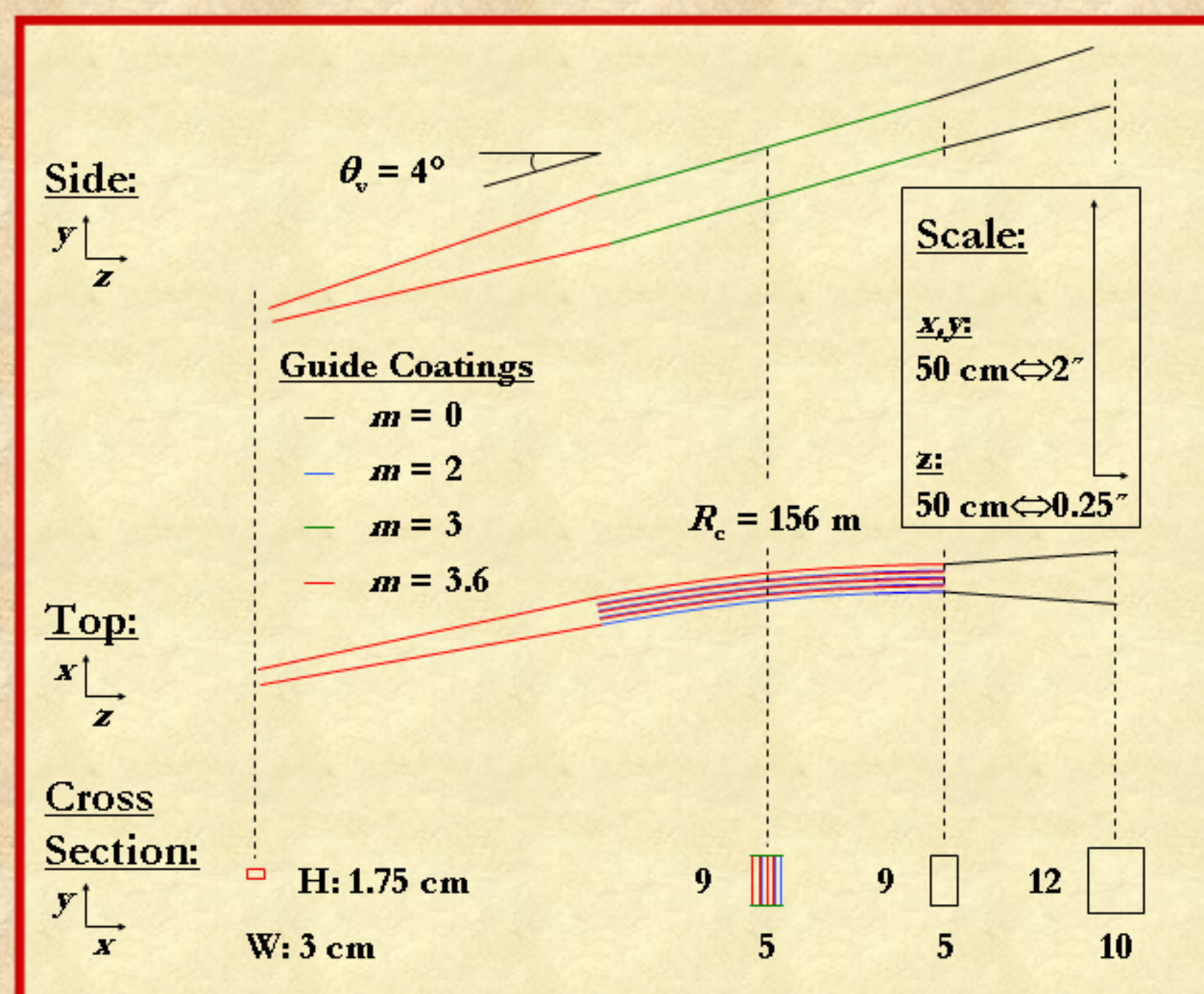
The Liquids Reflectometer at the Spallation Neutron Source

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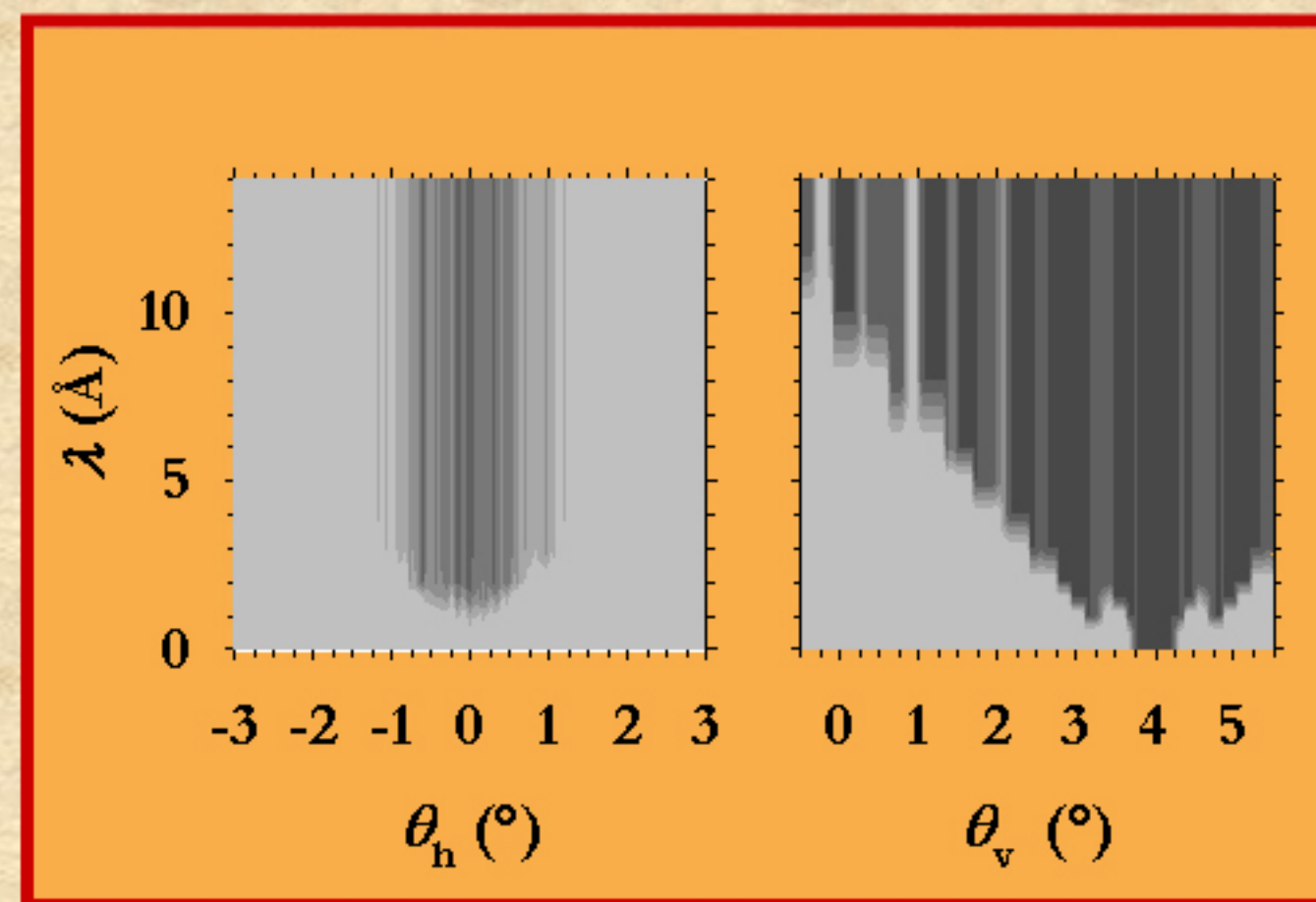
I. Liquids Reflectometer Neutron Optics



The liquids reflectometer will view a 20-K coupled super-critical H_2 moderator exhibiting peak flux at 2.5 Å.



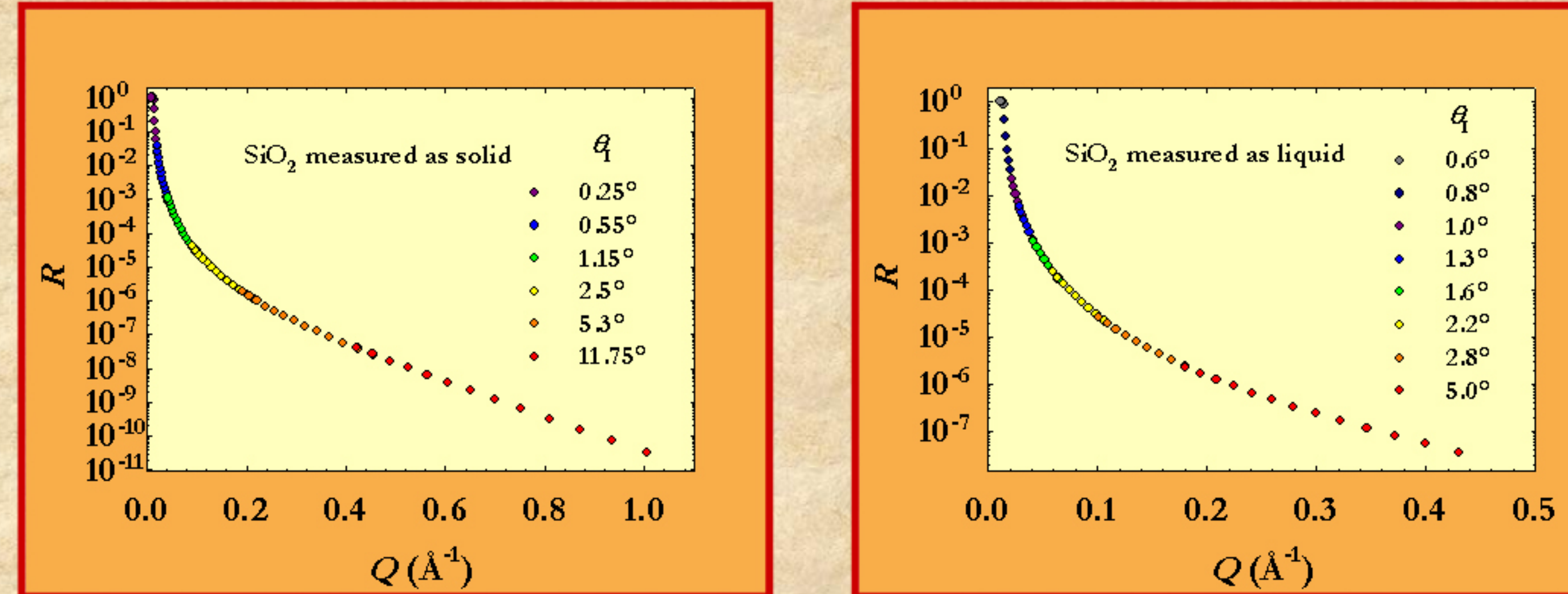
The incident optics feature a multi-channel beam bender followed by a doubly tapered neutron guide. The optics eliminates moderator line-of-sight and greatly reduces fast-neutron flux. The tapered guide creates vertical beam divergence that can be sampled to produce a range of angles of incidence onto a liquid surface.



A source of frequency f , area A , and flux Φ produces neutrons, traveling through optics of average reflectivity r with m bounces on average and horizontal X_h and vertical X_v optical acceptance (contours above), that are collected in $\Delta\lambda$ -wide wavelength bins:

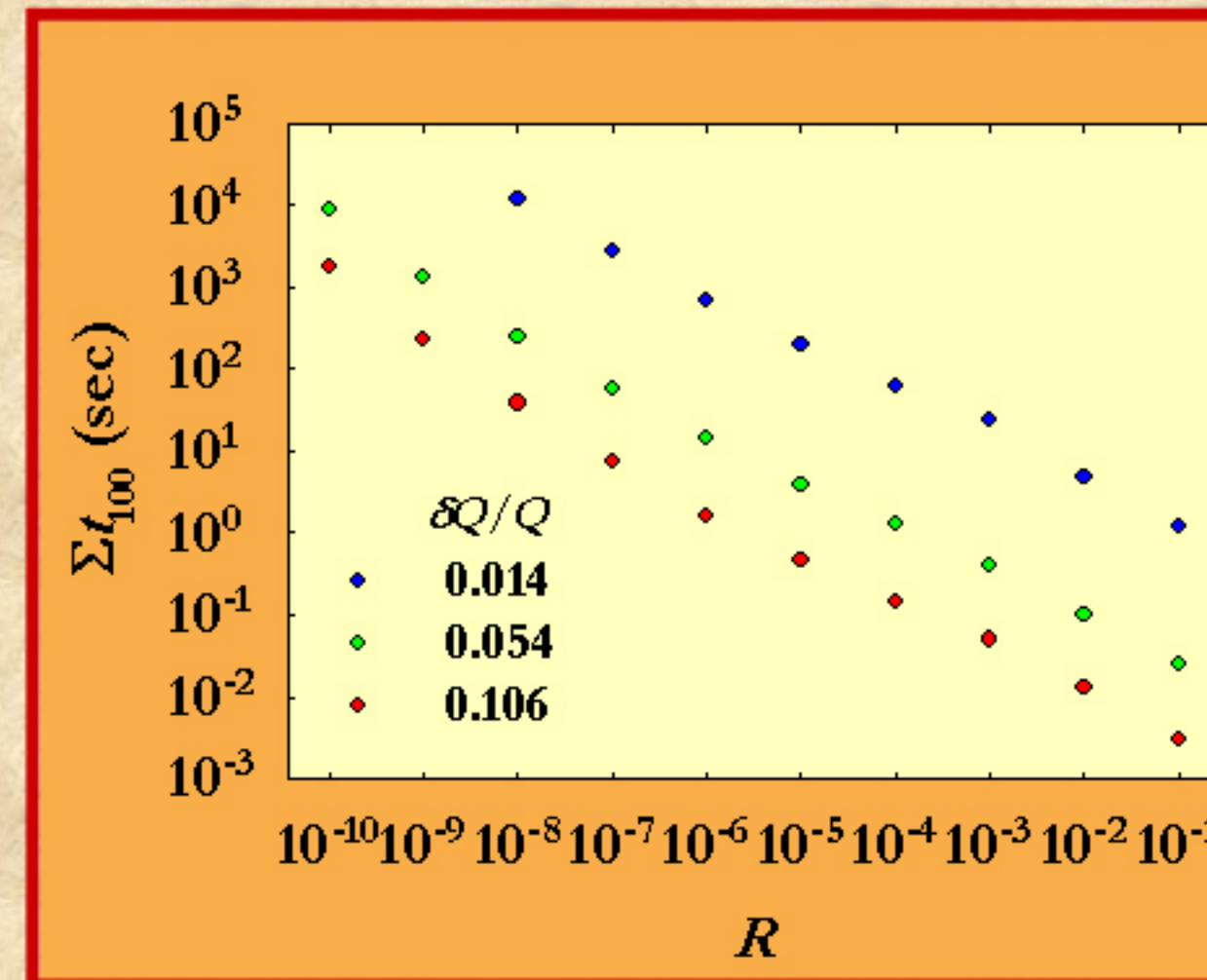
$$I = (f\Phi/A) \times X_h \times X_v \times r^m \times \Delta\lambda$$

II. Estimated Count Rates

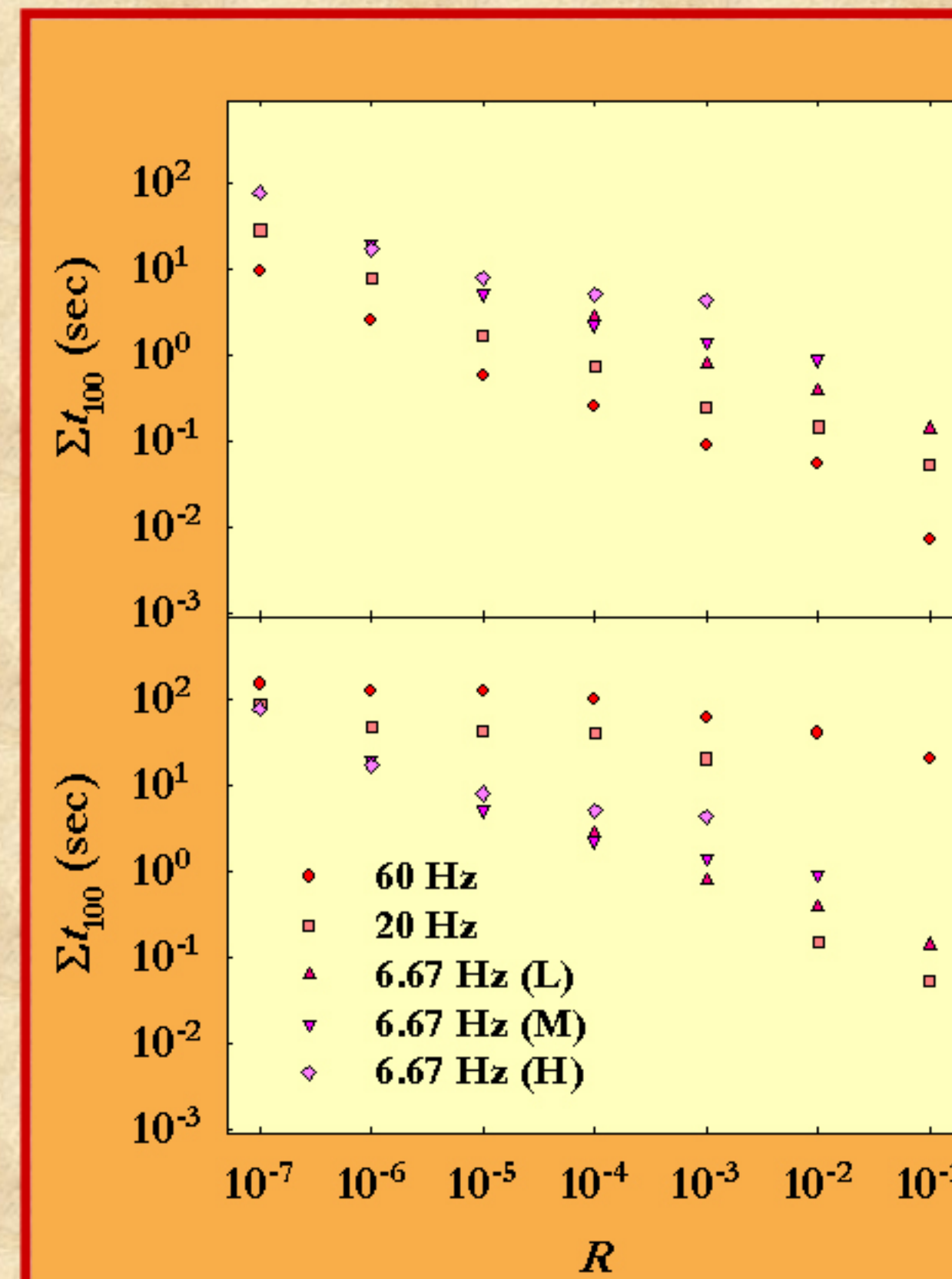


We measure specular reflectivity by employing multiple angles of incidence (labels above) and the 3.75-Å-wide usable wavelength bandwidth of the 2 MW 60-Hz SNS. A solid sample (left) can be tilted and so can utilize the maximum intensity available on the beam centerline ($2.5 \text{ Å} \leq \lambda \leq 6.25 \text{ Å}$). By contrast, in measuring a liquid surface (right), one utilizes vertical divergence and long wavelengths to cover a more restricted Q range using a larger number of incident angles.

The time Σt_{100} required to accumulate at least 100 counts in the least-intense wavelength bin at each incident angle used to measure from the critical angle out to a given reflectivity on a solid sample increases as $\Sigma t_{100} \sim R^{-0.6}$. High-resolution measurements (small $\delta Q/Q$) require longer counting times.

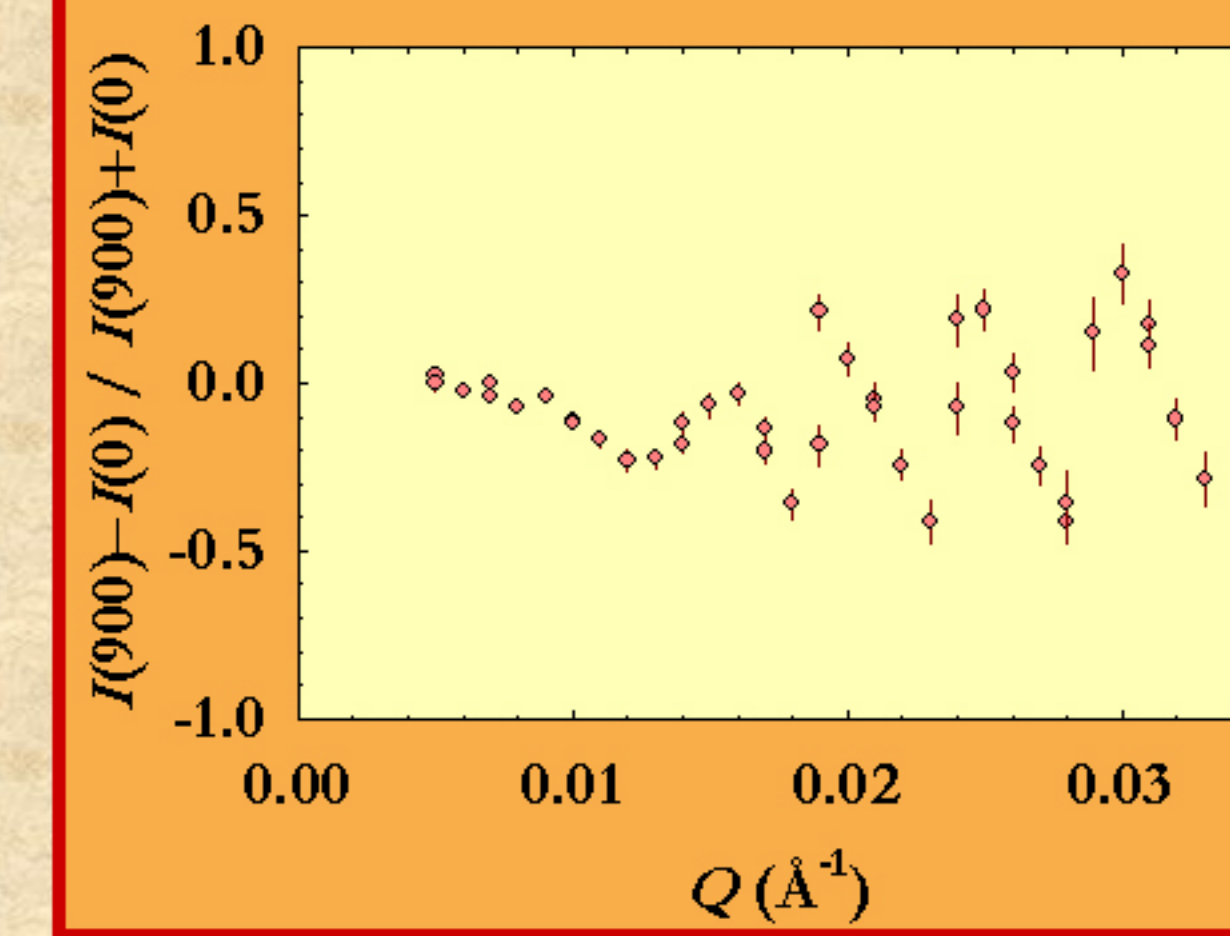
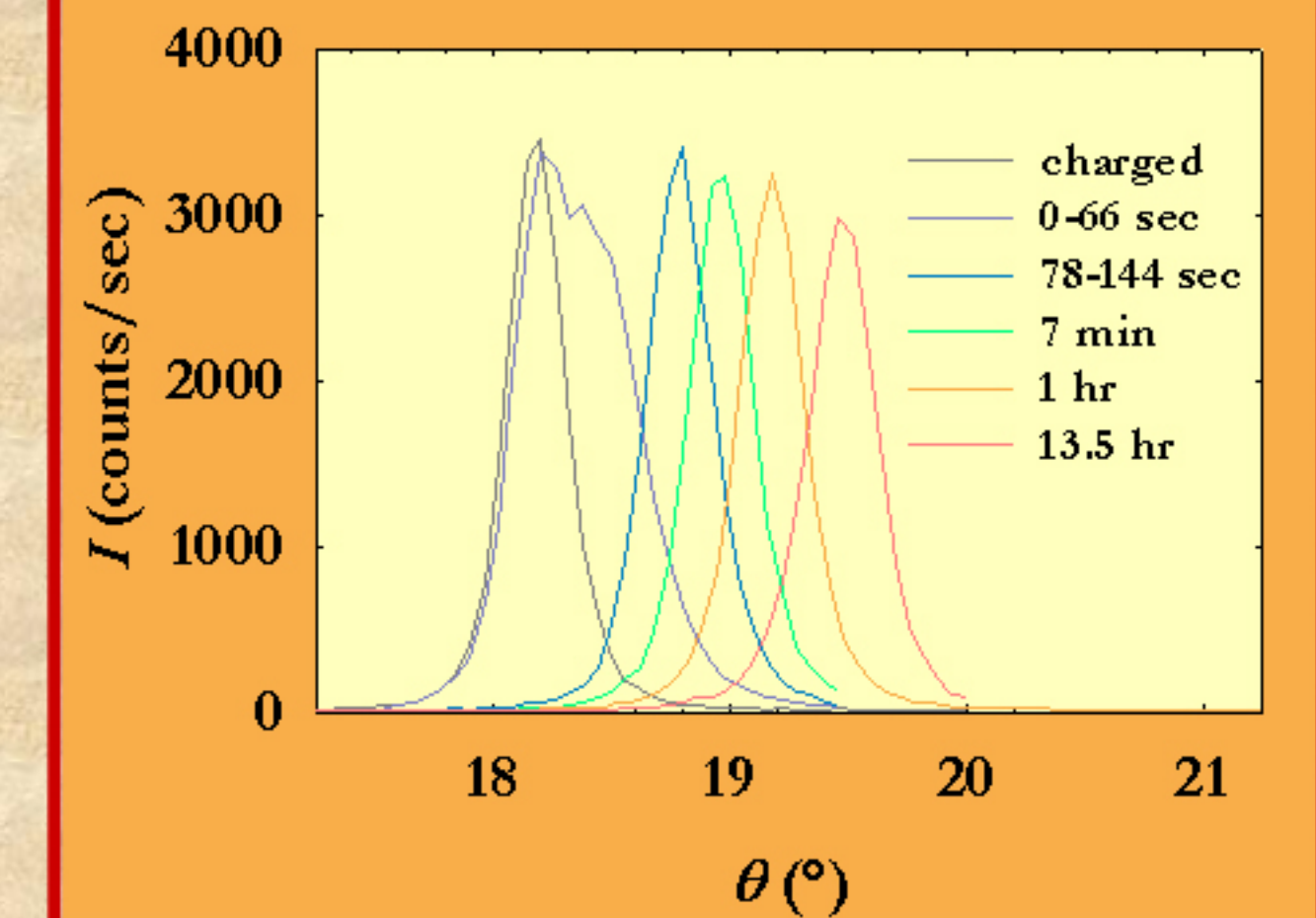


Due to the use of less-intense wavelengths, liquid sample data collection times are longer than those for solid samples. By operating the bandwidth choppers slower than the 60-Hz source frequency, we can broaden wavelength bandwidth at the cost of throwing away pulses. However, when we account for the ~20 sec time needed for a liquid surface to settle after being moved, lower frequency measurements may be more economical. The upper plot shows raw counting time for 60 Hz (8 angles, see above), 20 Hz (4 angles), and (L)ow, (M)edium, and (H)igh angles measured at 6.67 Hz. The lower plot shows counting time plus a 20-sec penalty for each change of angle.

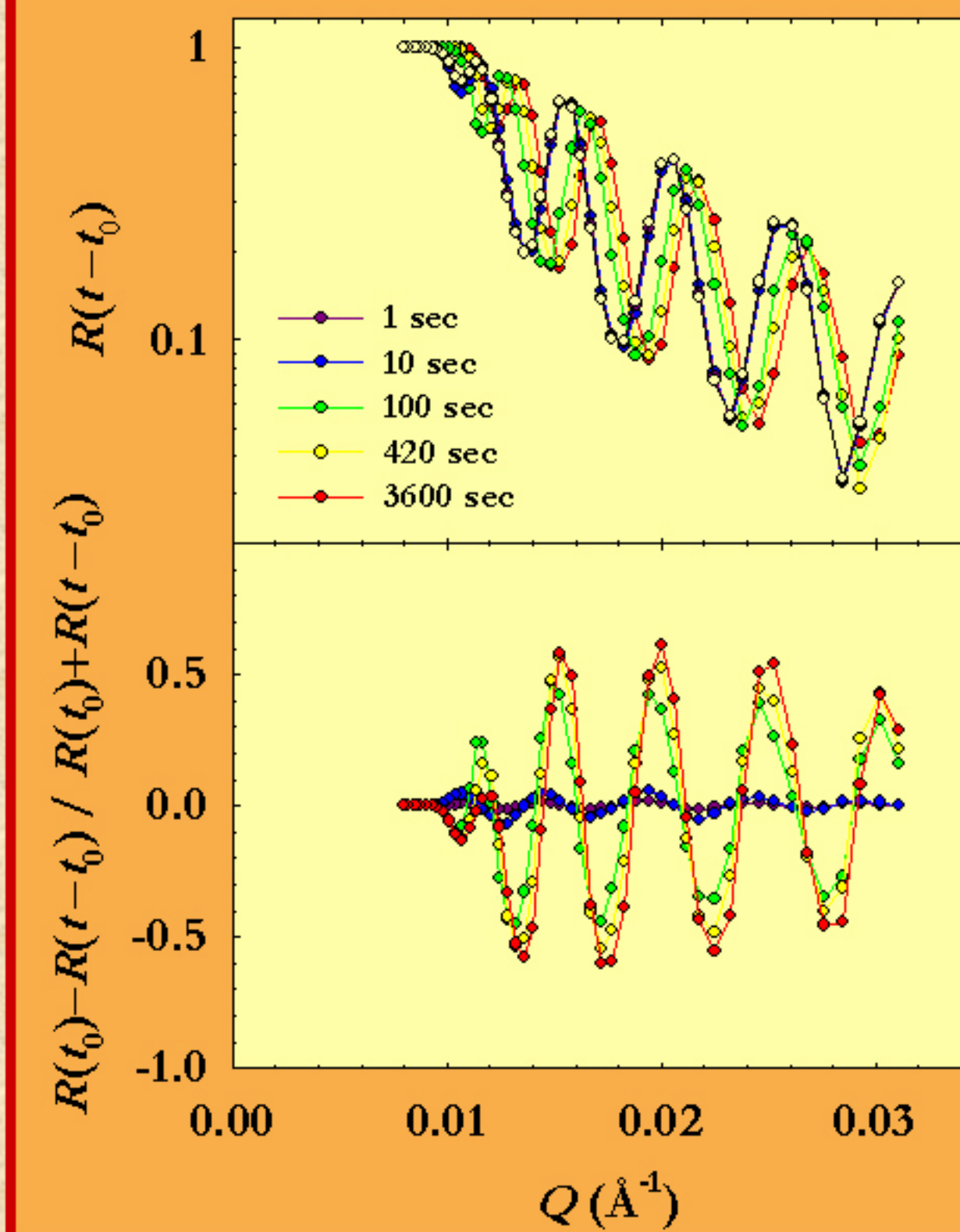
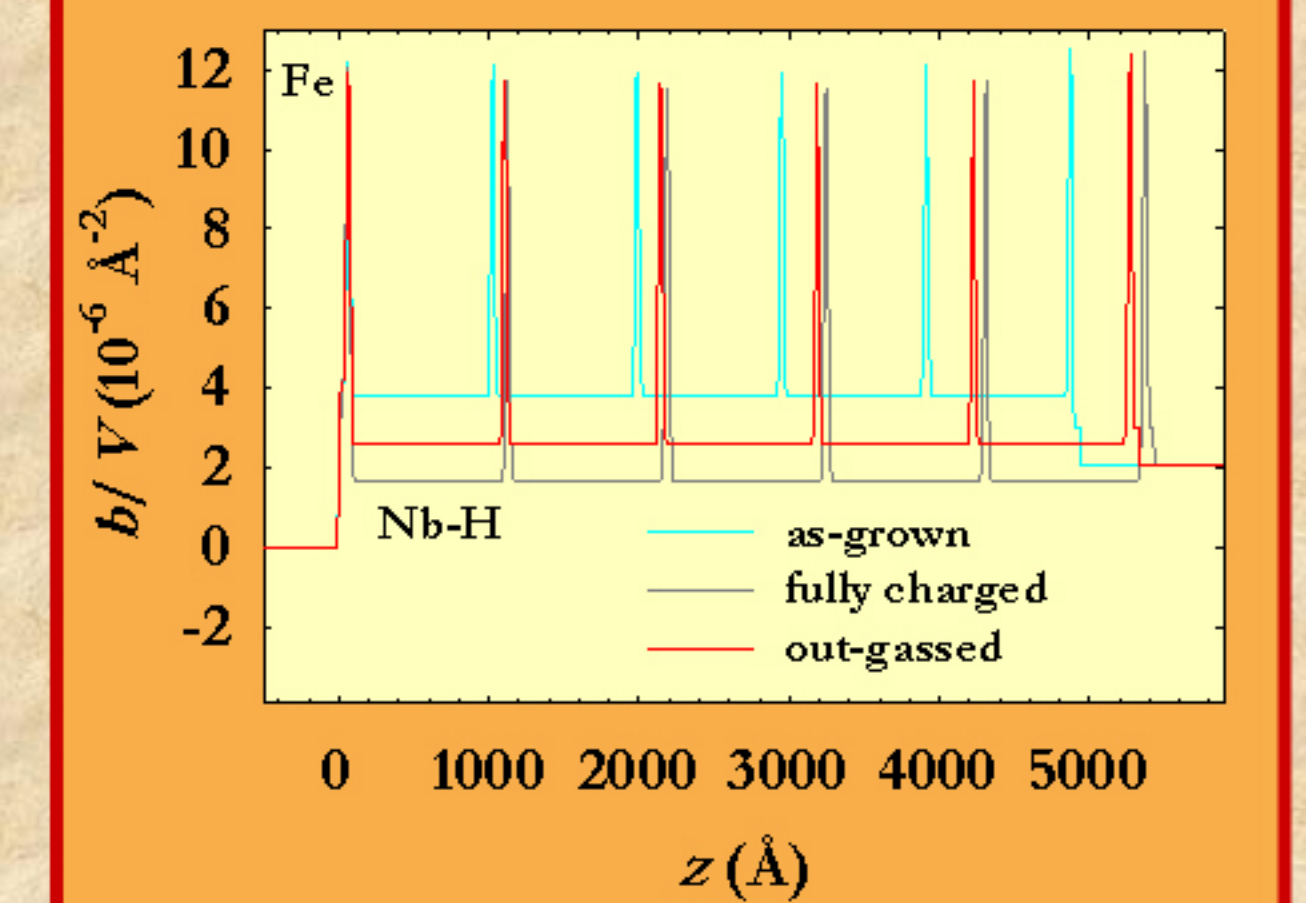


III. Case Study: Fe/Nb-H Multilayer

Rehm, et al. [PRB 59, 3142 (1999)] prepared a $[26 \text{ Å Fe} / 1000 \text{ Å Nb}]_5$ film and charged it with H_2 at 900 mbar. The plot (right) shows the time evolution of the Nb x-ray ($Cu_{K\alpha}$) Bragg peak during out-gassing.



The fitted scattering density profiles (right) of as-grown, fully charged, and out-gassed films reveal that not all H leaves the film during out-gassing.



The plots above show calculated reflectivities and difference spectra for an out-gassing time series derived from the x-ray and neutron data. On the right are the earliest time scans calculated using simulations of the SNS liquids reflectometer assuming $\delta Q/Q = 0.104$. Achieving 1 second time resolution seems feasible.

